Electric System Seismic Safety & Reliability Study

Contract #: 700-99-002
Contractor: Pacific Gas and Electric Company
Subcontractors: University of California, Berkeley
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Match Amount: $5,400,000
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Status: Completed

Project Description:
The greatest single natural-hazard threat to electric system reliability in California is the likely occurrence of a major urban earthquake. The 1989 Loma Prieta and 1994 Northridge earthquakes, although deadly and destructive events, were only a portent of potential future earthquake effects and should serve as a warning to all aspects of society to increase the state of earthquake readiness. Post-earthquake functioning of utility systems, in particular electric power service, are viewed by emergency responders and society in general as a vital need for rapid response and recovery from a major urban earthquake.

This project will fund "user-driven" research to support the development and rapid application of methods and technologies for reducing earthquake hazards and vulnerability, and improve electric system reliability and safety of electric transmission and distribution systems. This means that the users of the research results, namely utility engineers and operations personnel, initiate the identification of the specific needs for research, approve the scope of the research effort, and monitor the progress of the research to assure that practical, usable results will be obtained.

These results will enable faster post-earthquake restoration of customer service due to less damage and disruption of electric transmission and distribution service caused by future earthquakes, and by more accurate and immediately available post-earthquake information about the state of damage produced by future earthquakes. The results will also be available to be used, as appropriate, by businesses, industry, regulatory agencies, and the general public in the State to reduce earthquake vulnerabilities and respond more effectively to earthquake effects.

PEER (Pacific Earthquake Engineering Research Center) is a consortium of 18 research universities located in California and other western states that has received National Science Foundation support for research in earthquake engineering and related fields. The PG&E-PEER Business and Industry Partnership was formed in 1996 to address, in a user-driven manner, important earthquake issues encountered by electric utilities operating in earthquake-
prone regions.

The goal of this applied research program is to improve the earthquake safety and reliability of electric power transmission and distribution in California. The research program was organized by the Joint Management Committee (JMC) to assure that research results would directly address utility needs in preparing for future earthquake occurrences, and that the results could be quickly implemented by utility personnel or their consultants.

This project supports the PIER Program objectives of:

- Improving the safety and reliability/quality of California's electricity by conducting research to enhance the stability of the electric system after major earthquakes.
- Enhancing local and state economies by minimizing the costs associated with power disruptions after a major earthquake.

Proposed Outcomes:

1. Develop technologies and protocols to mitigate the vulnerability of electric systems to damage directly and indirectly caused by earthquakes.
2. Develop assessment techniques to evaluate damage to electric systems caused by earthquakes and assess fiscal impacts due to the loss of electric service to the community.

Actual Outcomes:

Completed 108 projects that addressed the two proposed outcomes. These projects have provided useful results that meet utility needs in the seven topic areas. It is important to also note the integration of the projects to meet the goal of the program, namely to improve utility earthquake performance. The following bullets summarize, in a narrative form, the cumulative connections between the topics that address this goal.

- Topic 1 results (earthquake ground motions) are used as input to Topic 2 (site response) and Topic 3 (permanent ground deformation) studies.
- Topic 1 results are used as input to assess the vulnerability of substation components and interconnected equipment, as well as equipment qualification testing (Topic 4). Severe ground shaking and ground failures are the direct causes of substation damage that can disrupt power transmission to customers.
- Topic 1, 2, and 3 results improve the assessment of building damage (Topic 5) before earthquakes occur to help identify appropriate mitigation and risk management strategies, and immediately following an earthquake (with Topic 7) to aid in emergency response and recovery activities.
- System earthquake risk models (Topic 6) integrate information about hazards (Topics 1, 2, and 3) and building/equipment fragility (Topics 4 and 5) to estimate damage and functionality of the electric transmission and distribution system.

Although the connections among the individual projects are multi-faceted, a broad picture can be seen in the research results that enable utility personnel (and their regulatory counterparts) to have significantly improved information for taking actions regarding earthquake risks. These actions often include retrofitting a vulnerable building that houses office workers, changes in the procurement procedures and requirements for new equipment, upgrading old equipment and improving anchorages in substation yards, and modifying emergency response procedures to take advantage of new information. The customer benefits from these actions following an earthquake in terms of greater electric power reliability, and faster and less expensive recovery of the overall functioning of society. Of course, there will always be some utility system damage due to random failures of components or facilities, vulnerabilities related to aging infrastructure, and unknown or unexpected response of equipment. However, redundant electric system design and the operation skill of utility personnel can make the extent and duration of outages no worse than those of a winter storm.

Project Status:

The project is complete. Final Report Title: Electric System Seismic Safety and Reliability
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